W Physics Prospects and the Forward GEM Tracker

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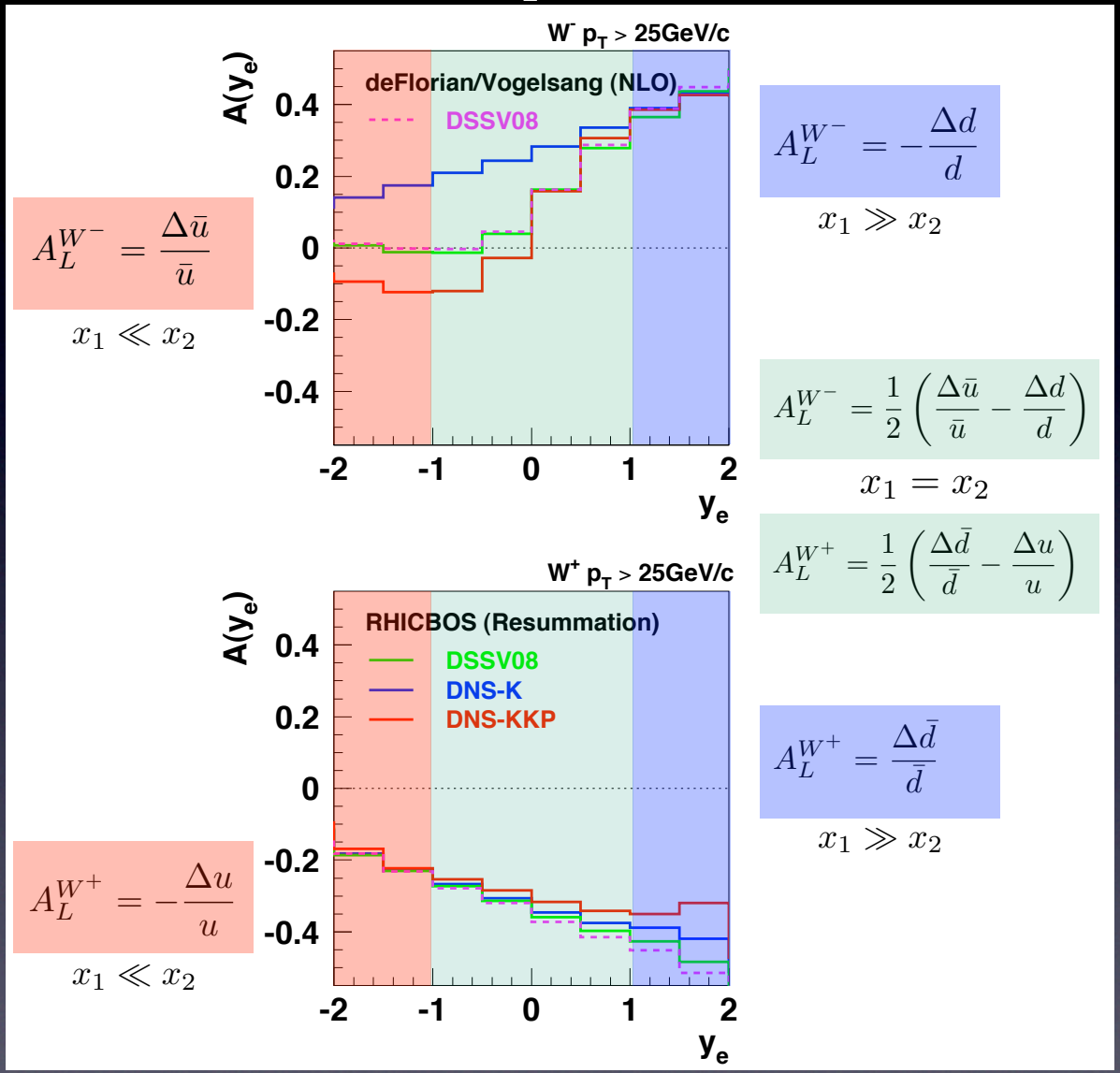
for the STAR Collaboration

Outline

- Motivating the Forward Gem Tracker (FGT)
- FGT Design
- Current Status of the FGT
- W measurement Projections
- Summary

Why We Want the FGT



$$A_L^{W^-} = \frac{\Delta\bar{u}}{\bar{u}} \qquad x_1 \ll x_2$$

$$A_L^{W^-} = -\frac{\Delta d}{d} \qquad x_1 \gg x_2$$

$$A_L^{W^-} = \frac{1}{2}\left(\frac{\Delta\bar{u}}{\bar{u}} - \frac{\Delta d}{d}\right) \qquad x_1 = x_2$$

$$A_L^{W^+} = \frac{1}{2}\left(\frac{\Delta\bar{d}}{\bar{d}} - \frac{\Delta u}{u}\right)$$

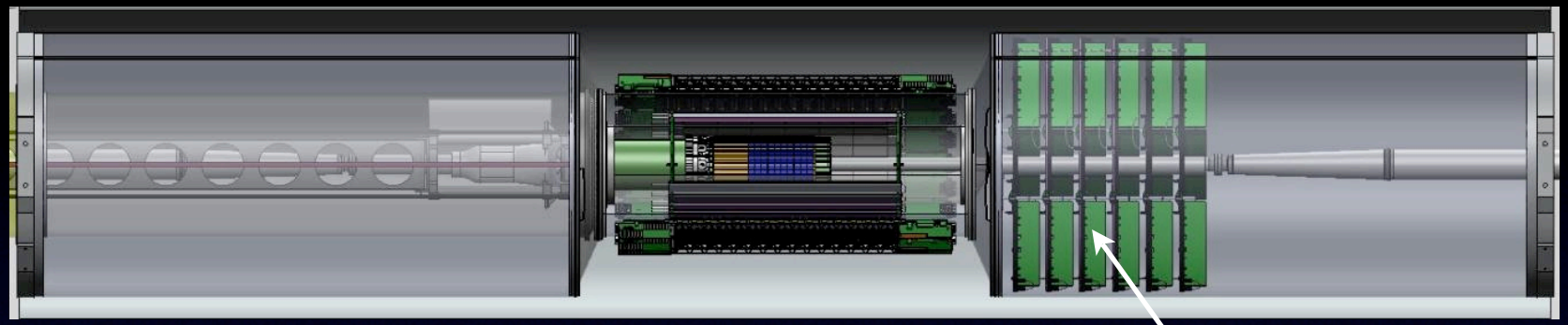
$$A_L^{W^+} = -\frac{\Delta u}{u} \qquad x_1 \ll x_2$$

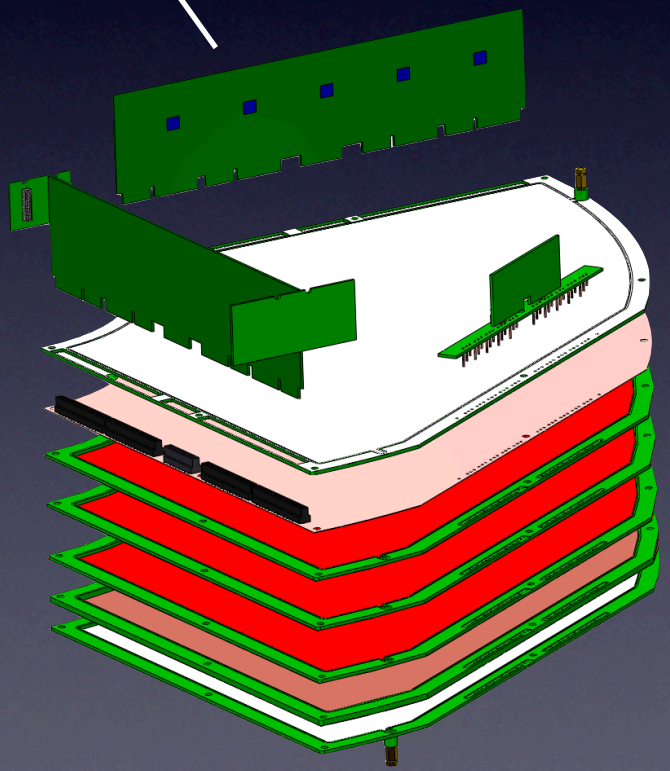
$$A_L^{W^+} = \frac{\Delta\bar{d}}{\bar{d}} \qquad x_1 \gg x_2$$

- Current global fits disagree in $1<|\eta|<2$
- We already have calorimetry in this range
- The FGT will provide tracking

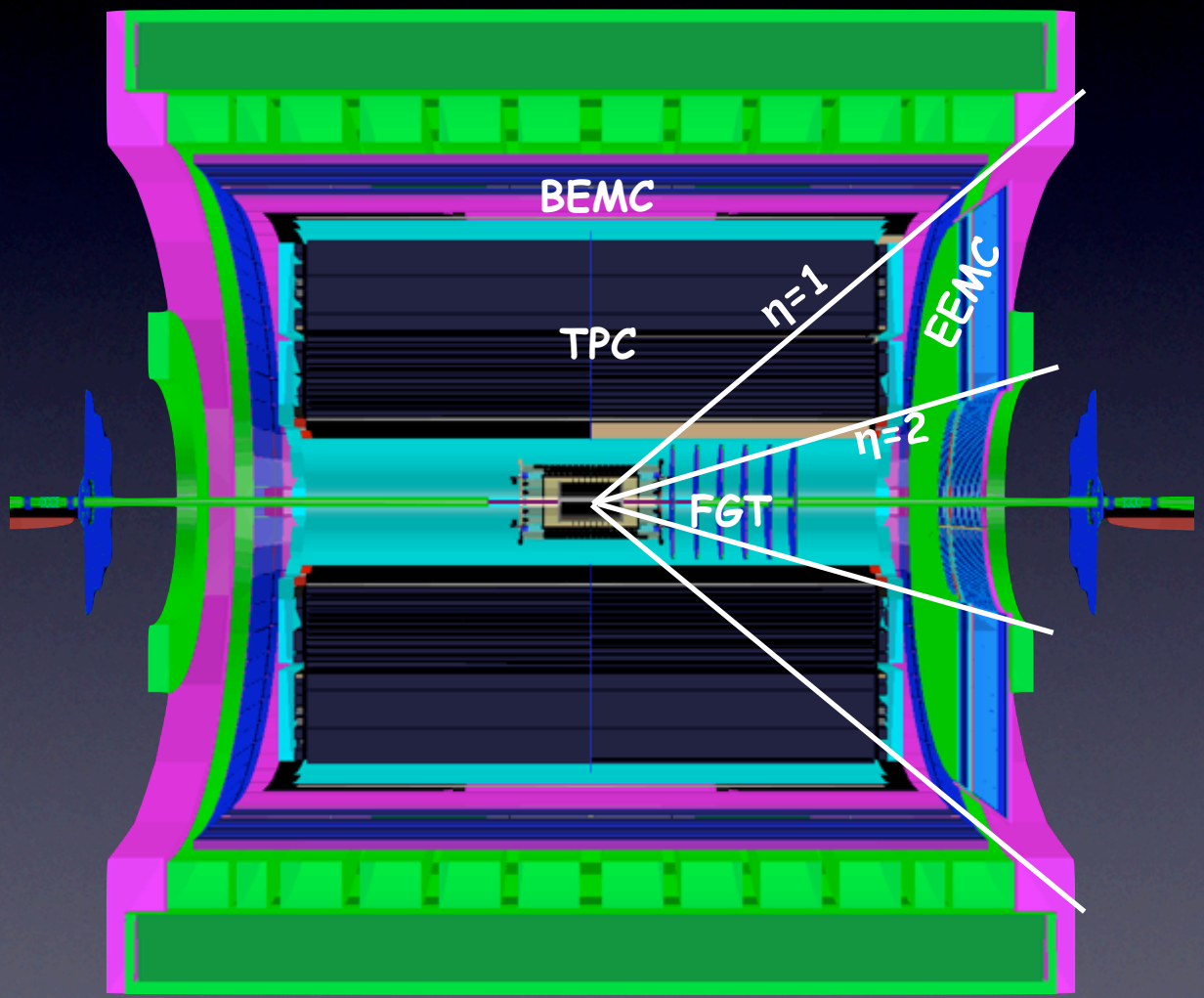
Calculations: 1) RHICBOS: P.M. Nadolsky and C.-P. Yuan, Nucl. Phys. B666 (2003) 31.
2) deFlorian / Vogelsang: D. deFlorian, private communications.

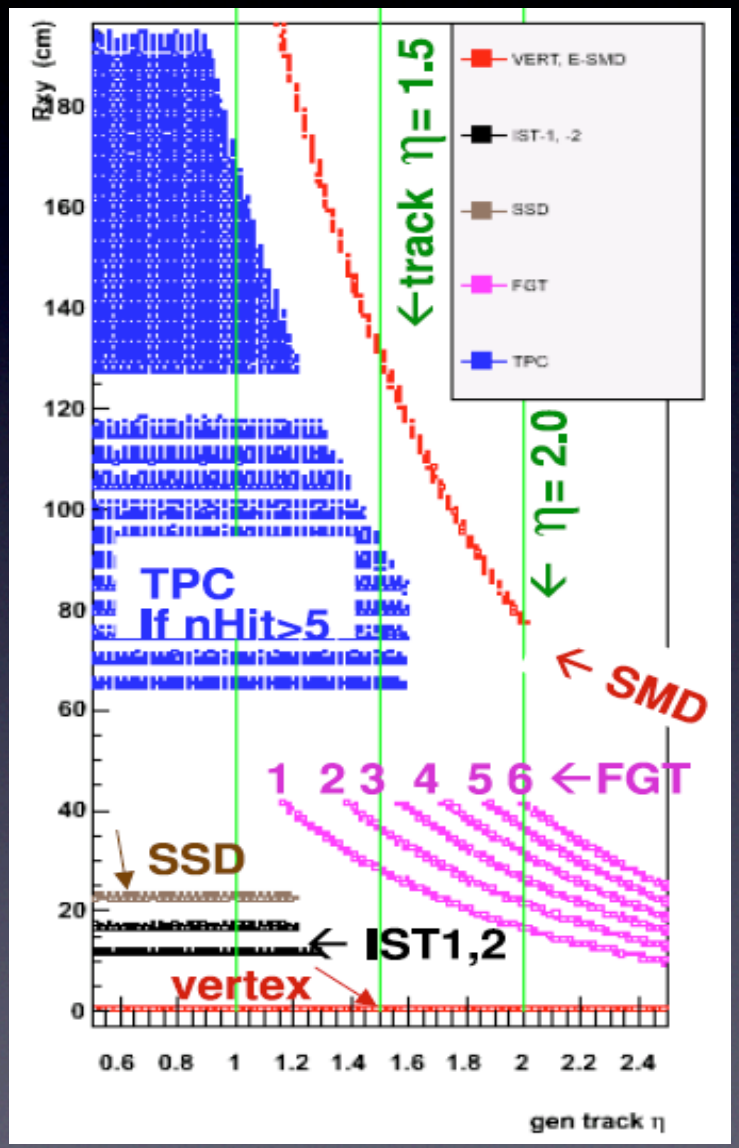
FGT Design





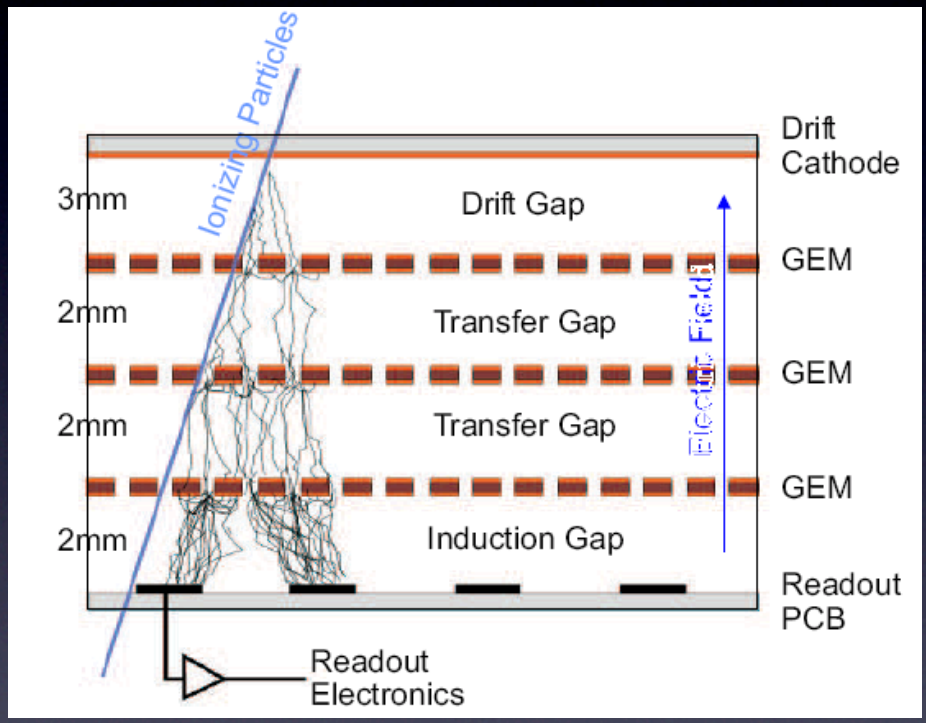
Tracking in 1<η<2



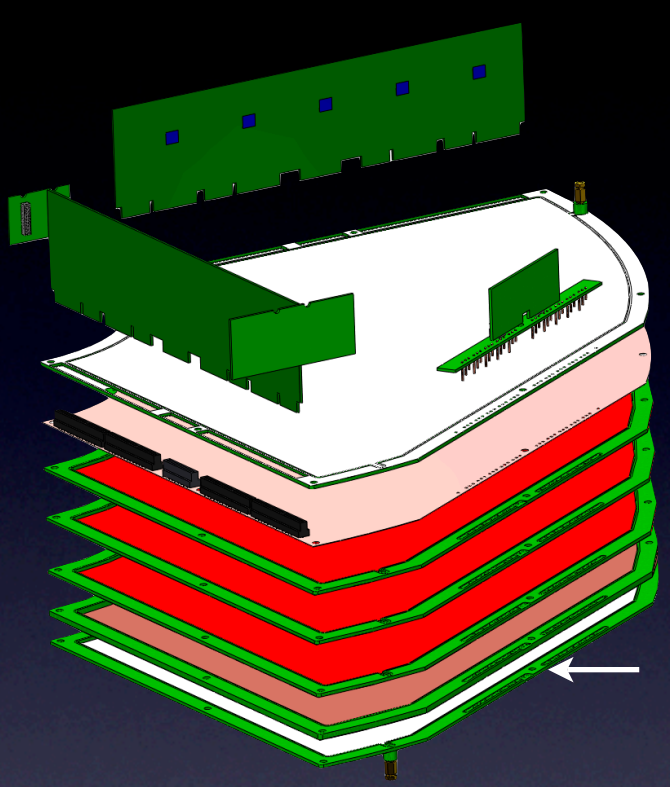


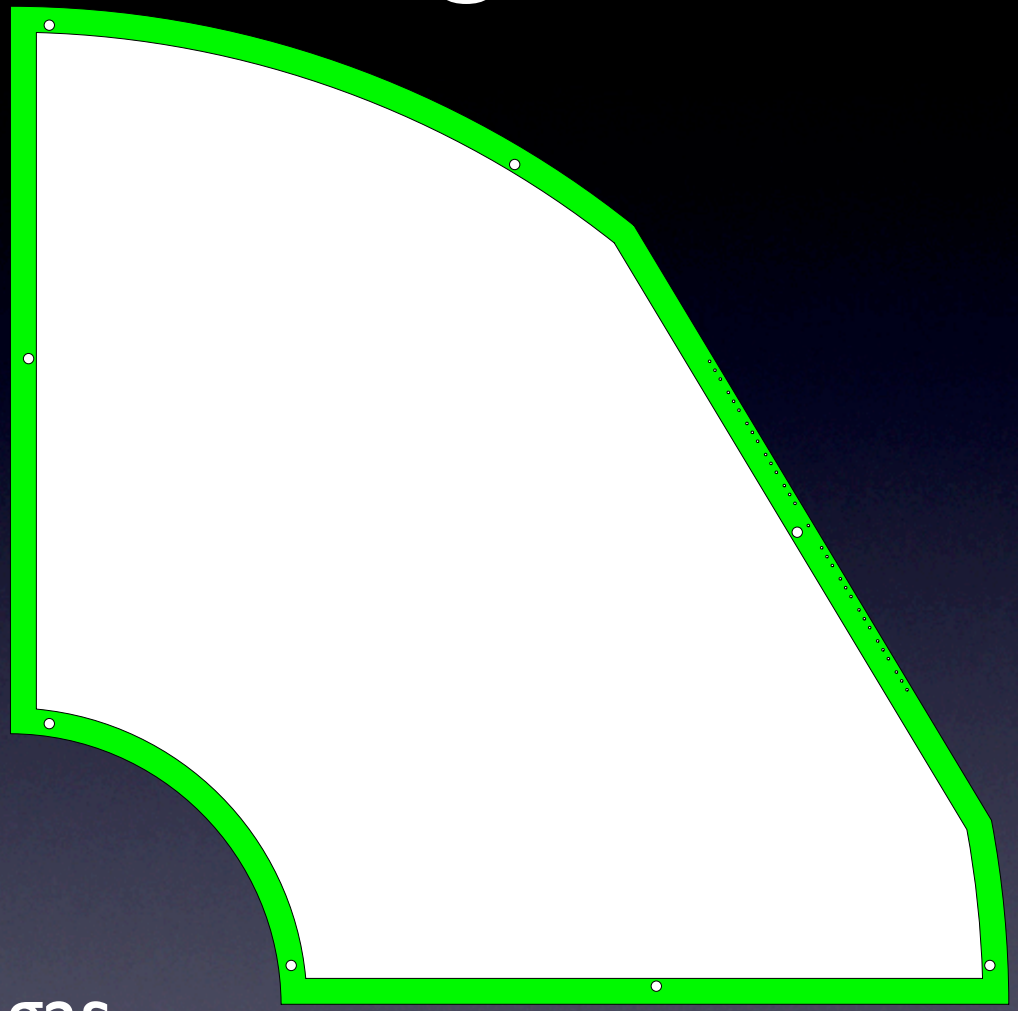
GEM Technology

- High gain (~10^6)
- Fast (<20ns FWHM, ~10^5 Hz/mm)
- Low mass
- Good spatial resolution
- Inexpensive
- Foils produced by CERN and Tech-Etch



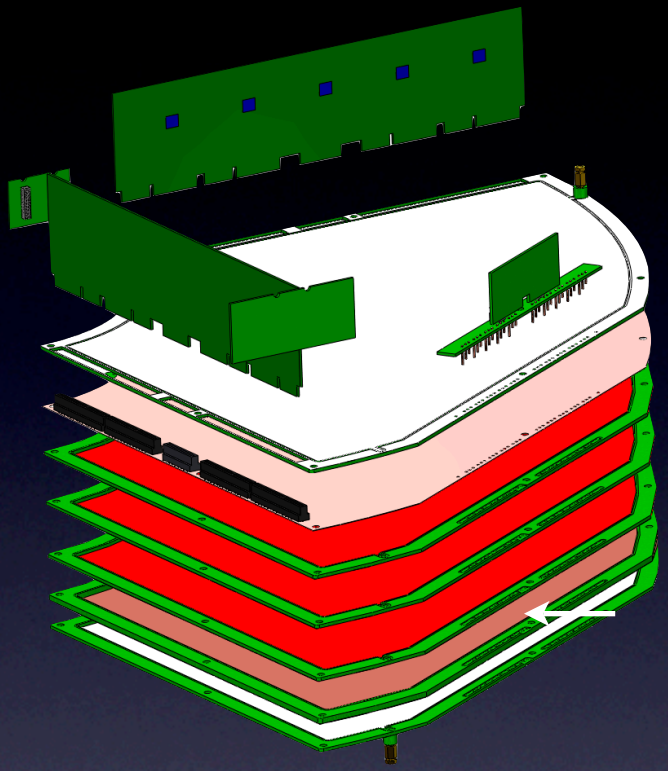
FGT Design

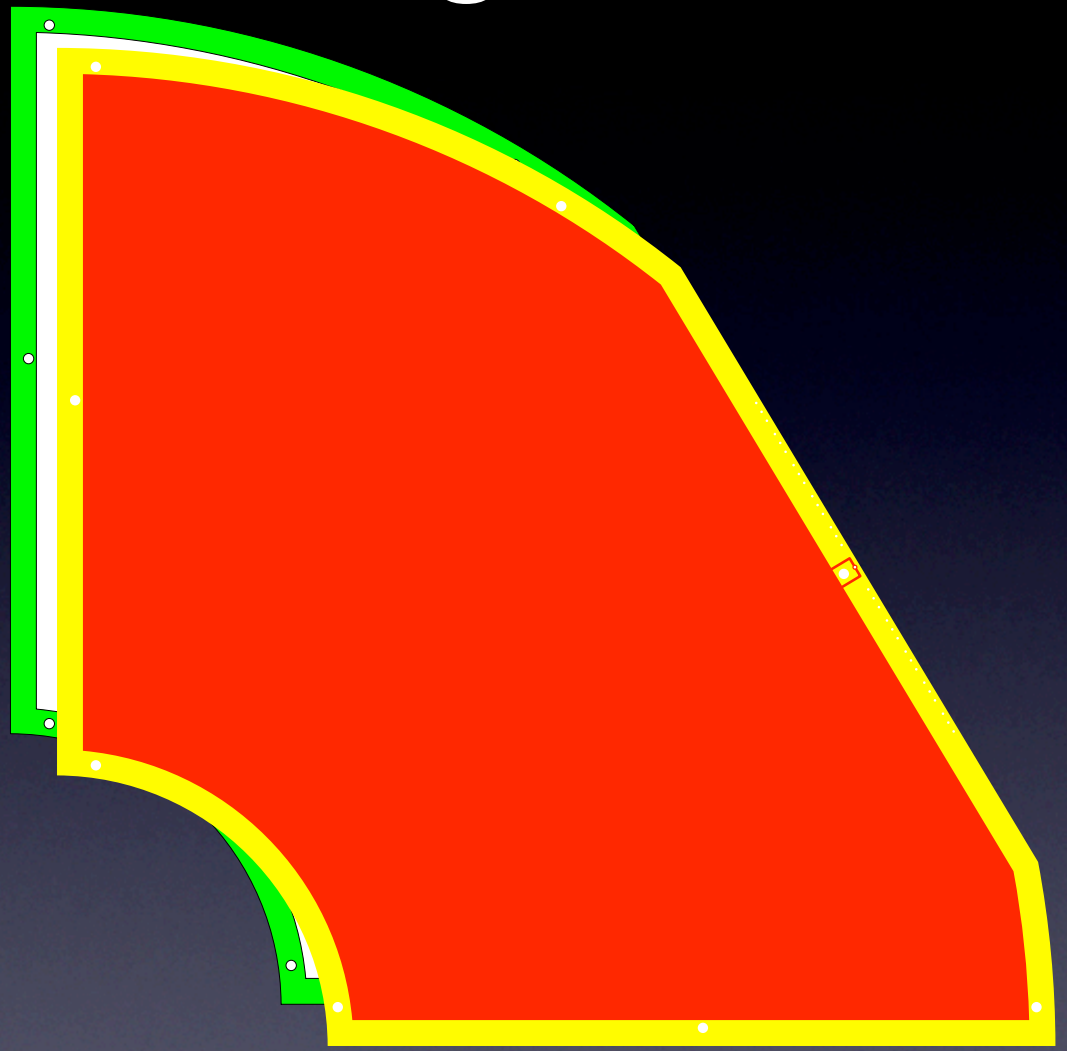




- Outer wall of gas volume, frame

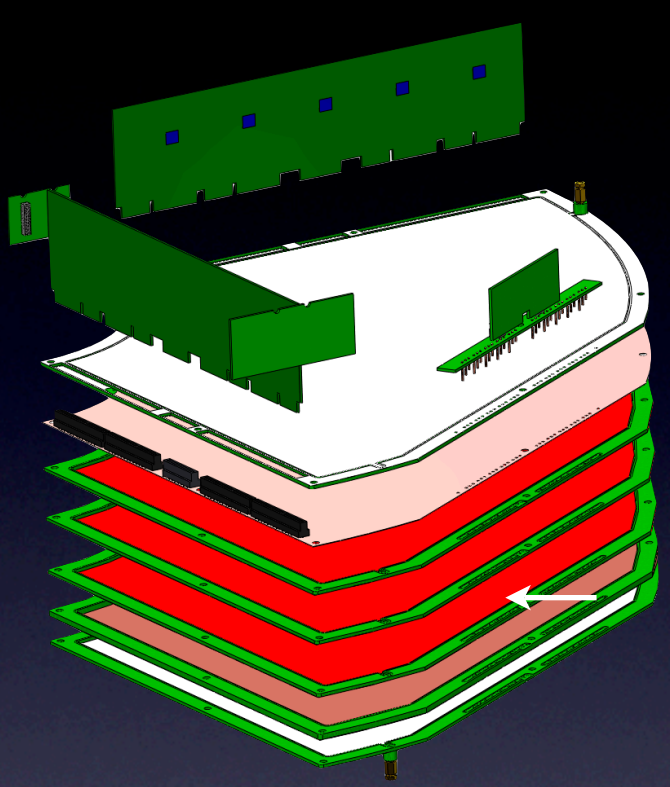
FGT Design

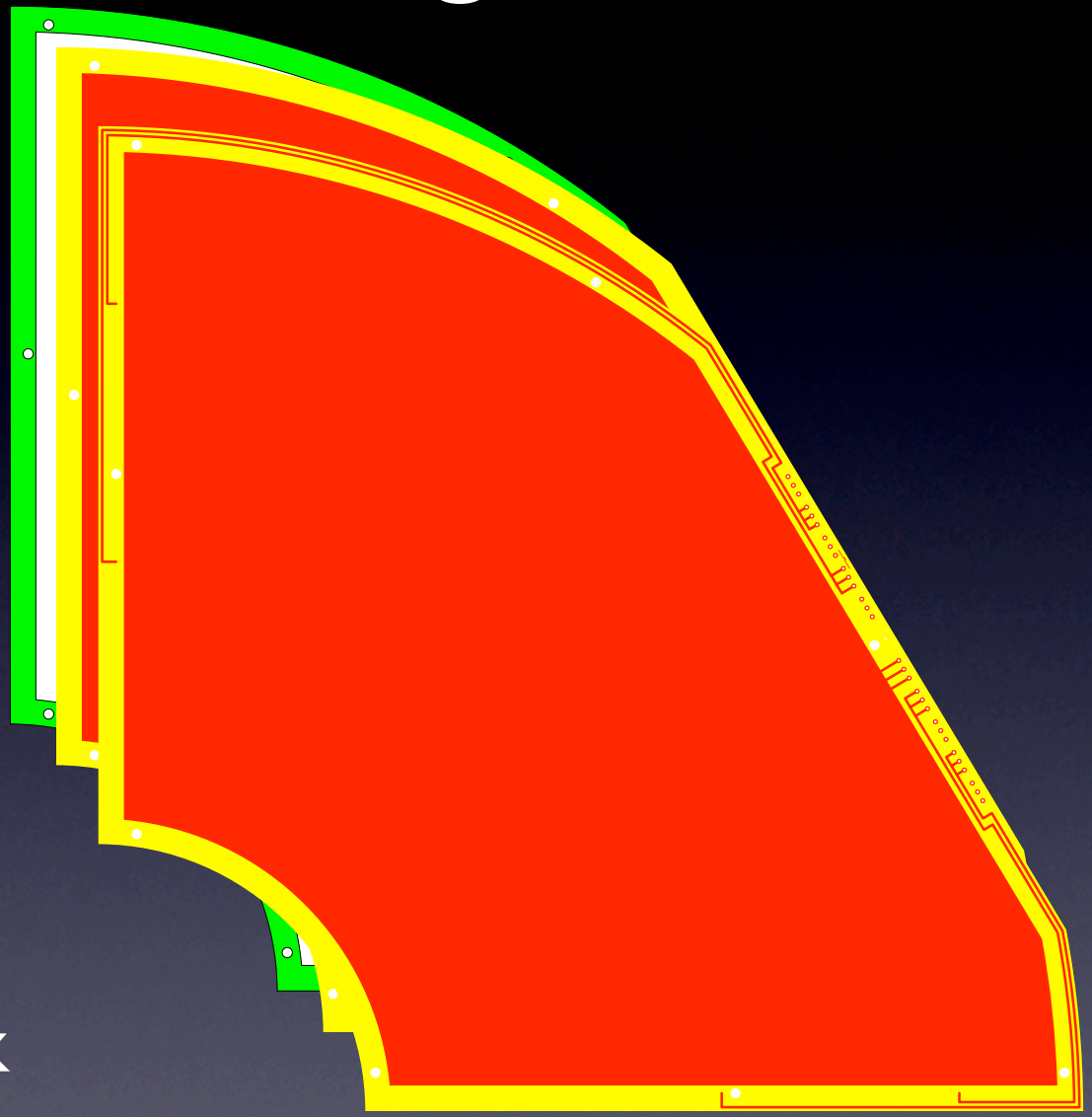




- HV plane

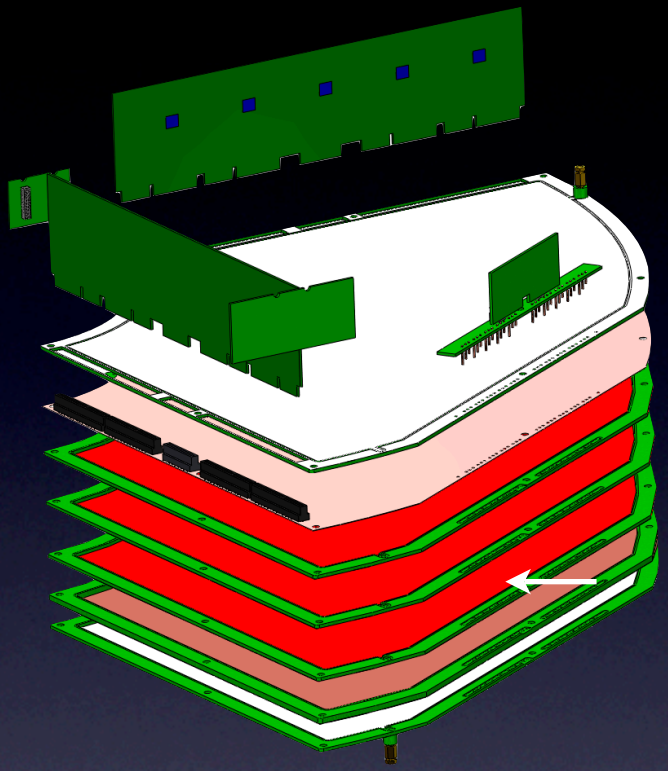
FGT Design

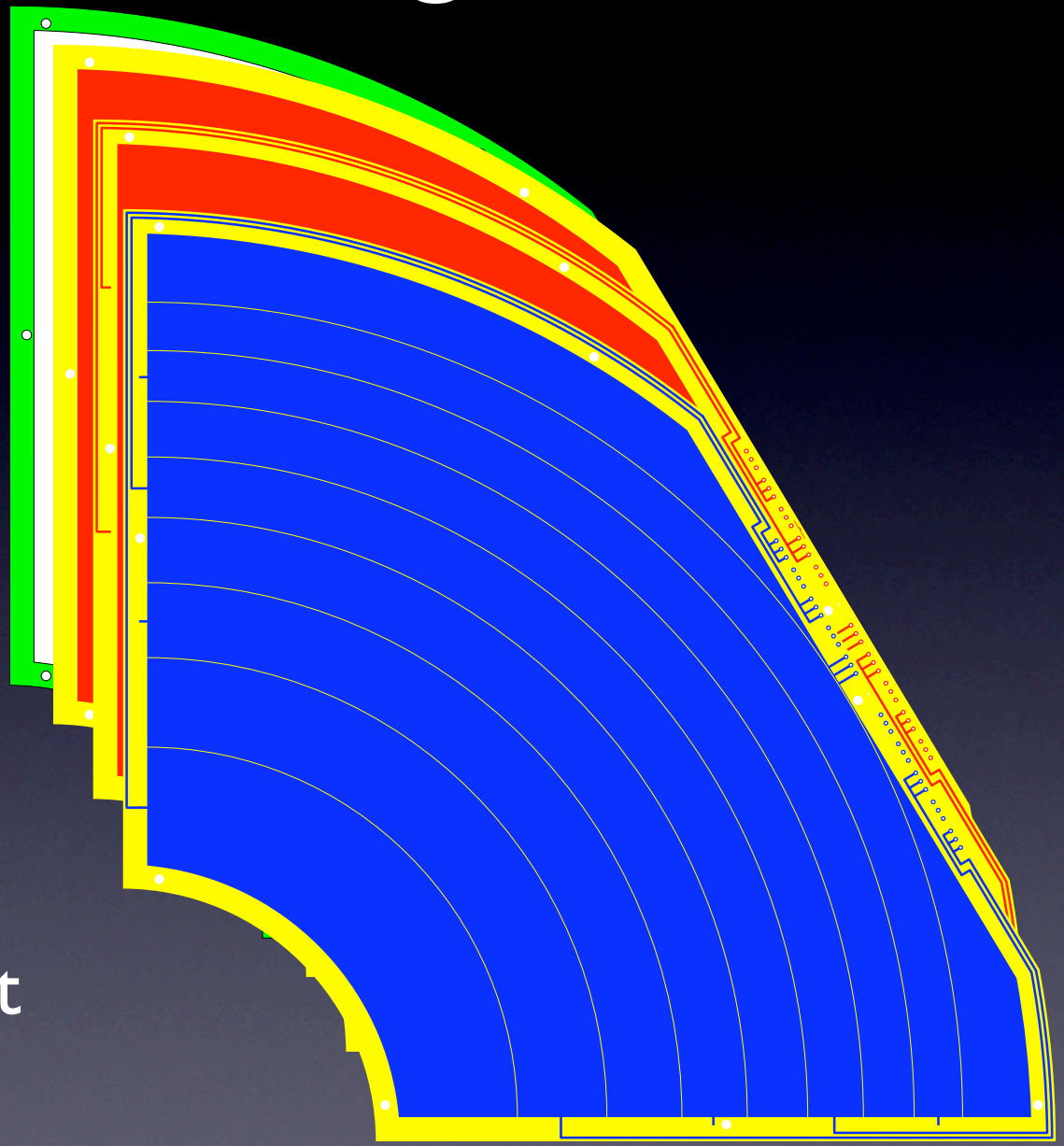




- GEM foil, back plane

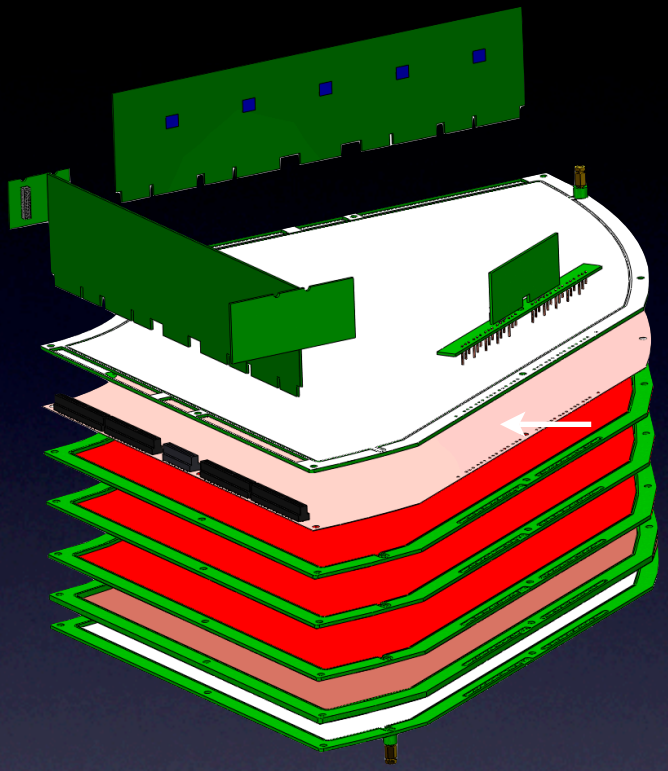
FGT Design

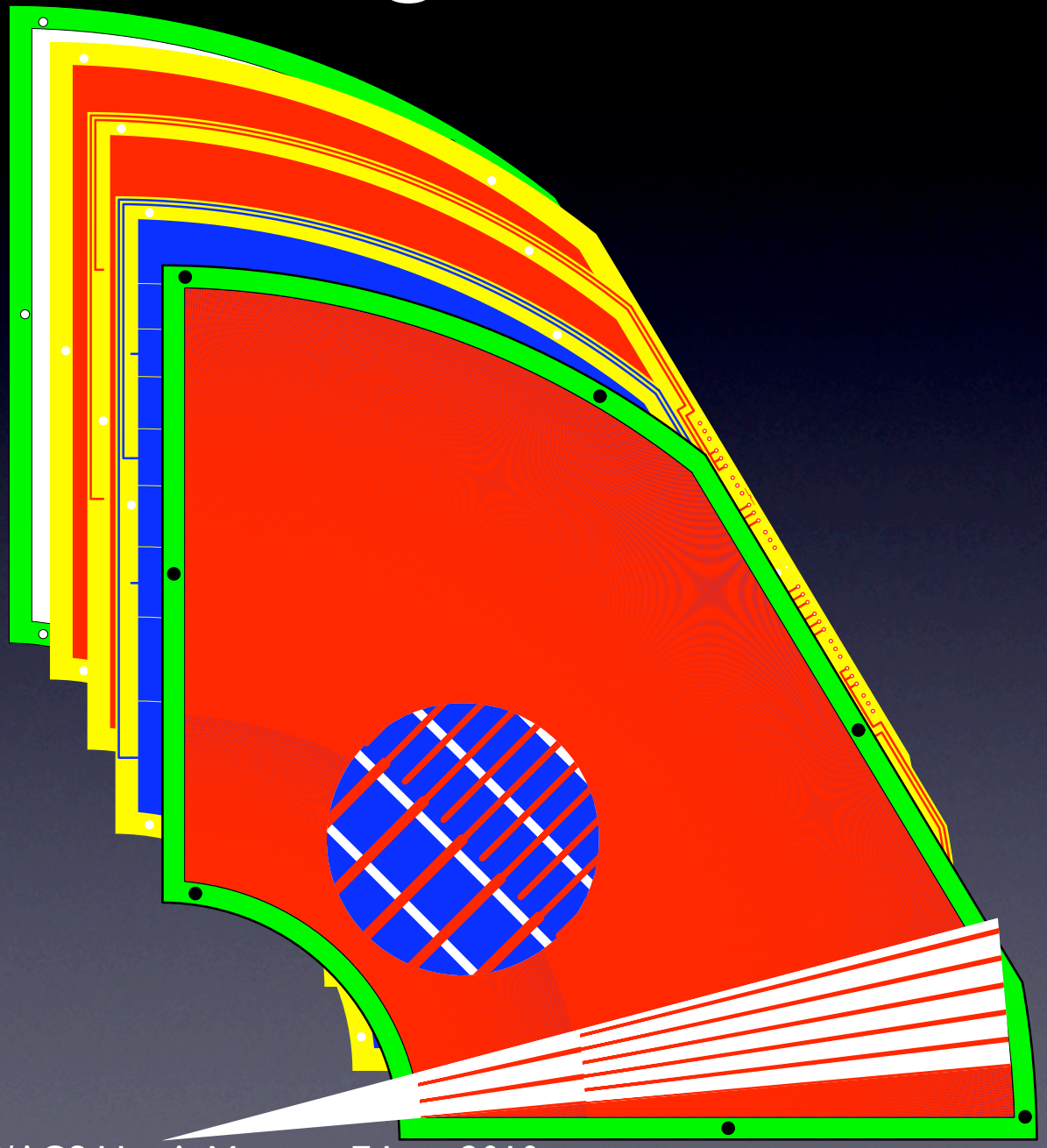




- GEM foil, front plane

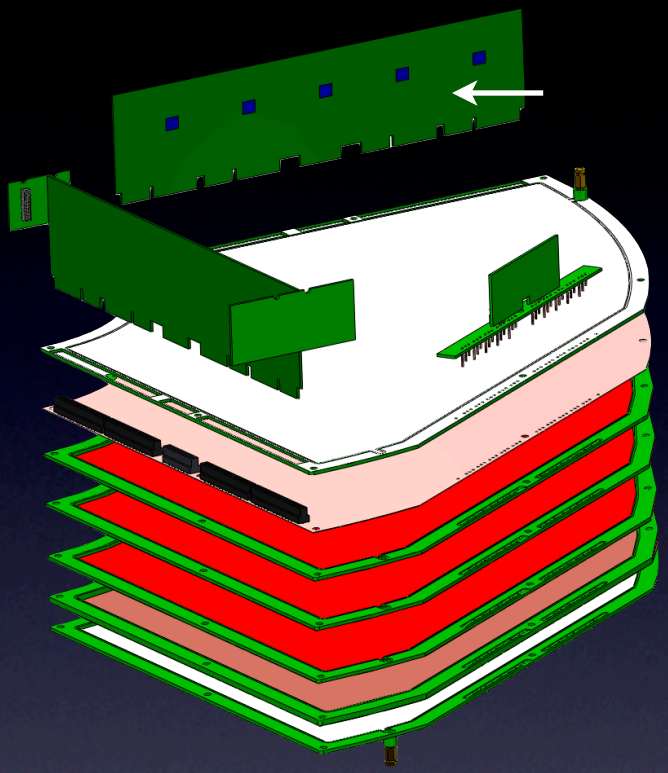
FGT Design

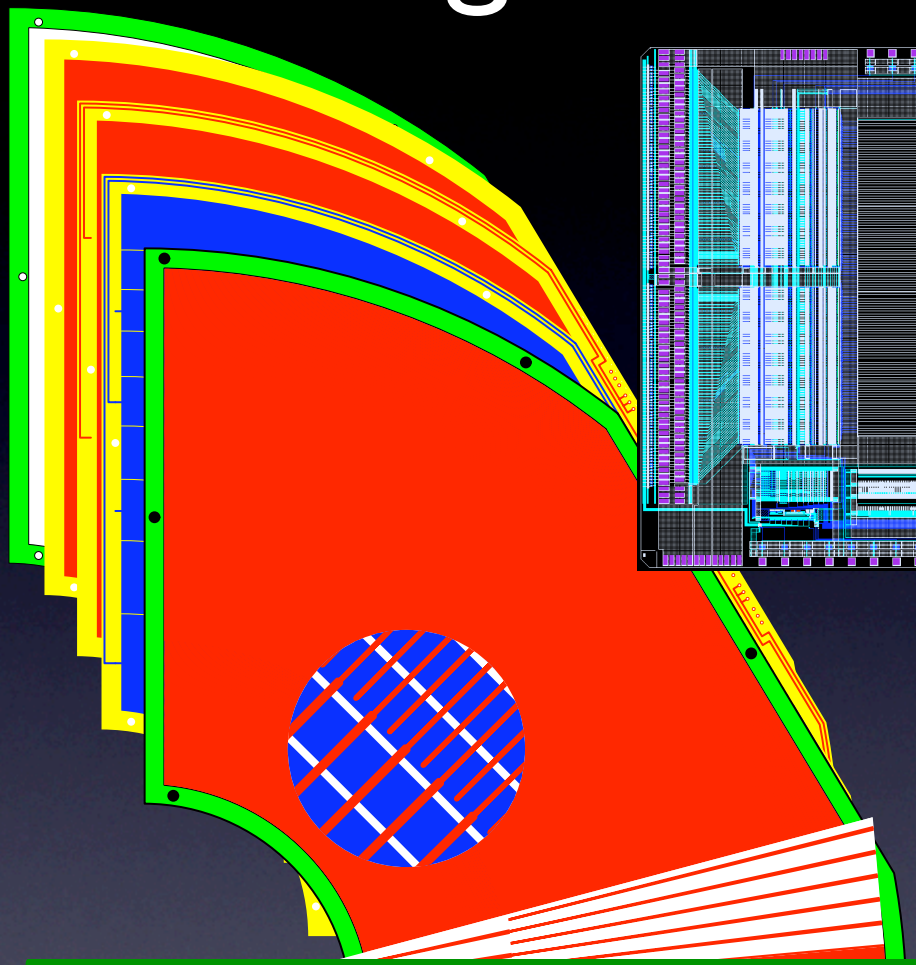


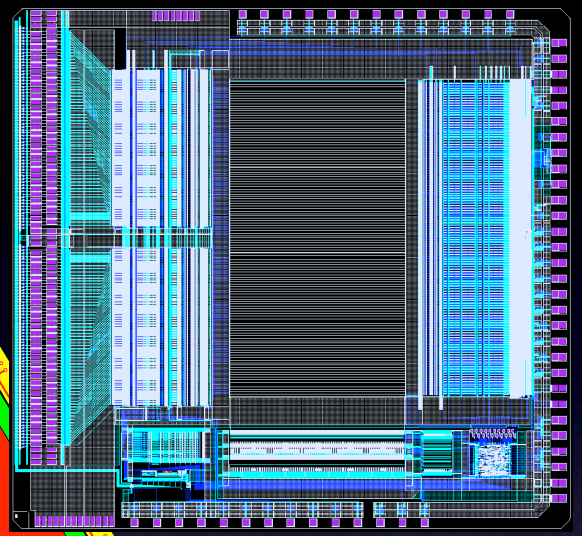


- 2D readout board

FGT Design

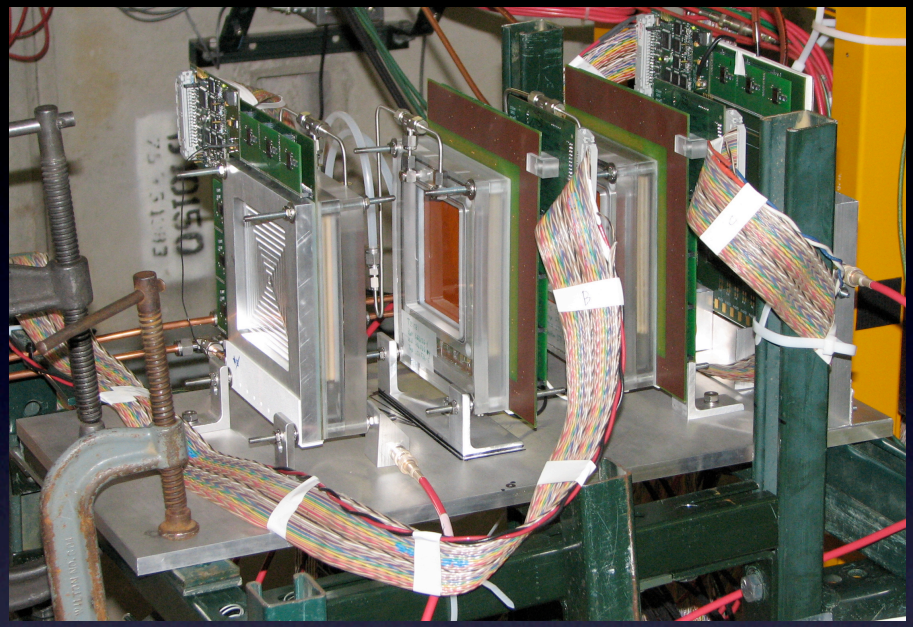


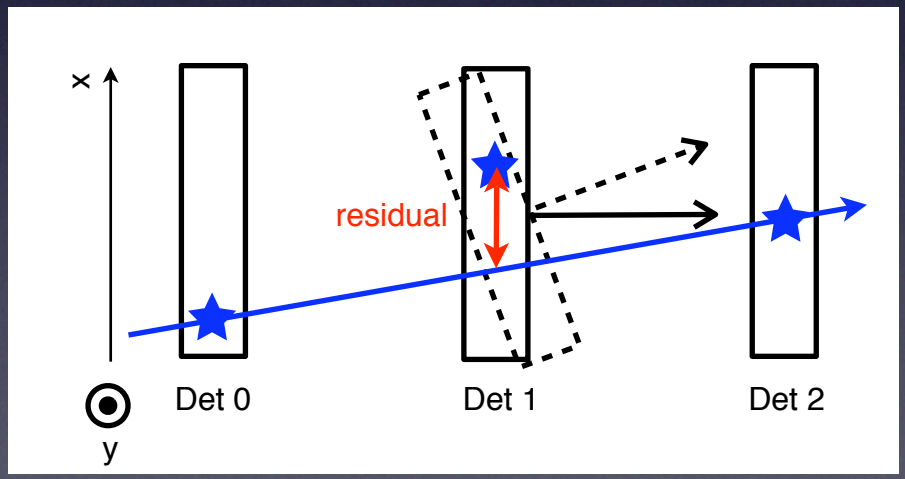


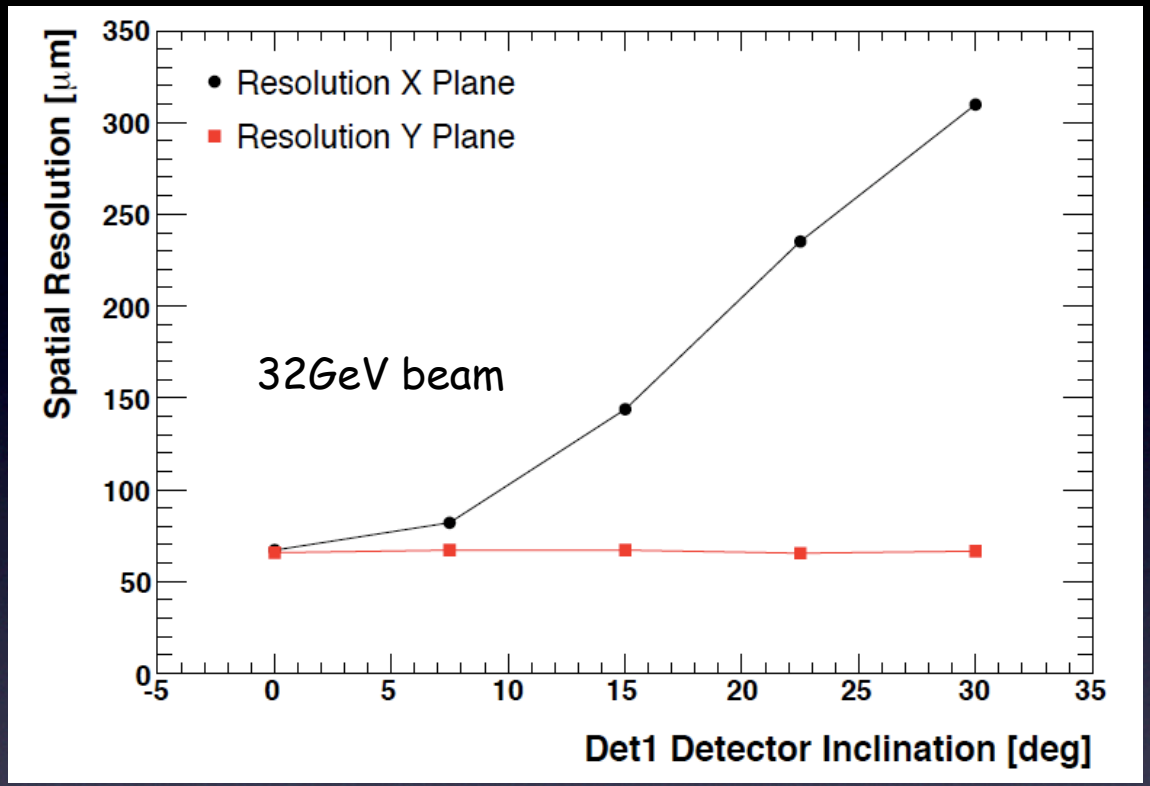


- Readout electronics

Test Beam Data



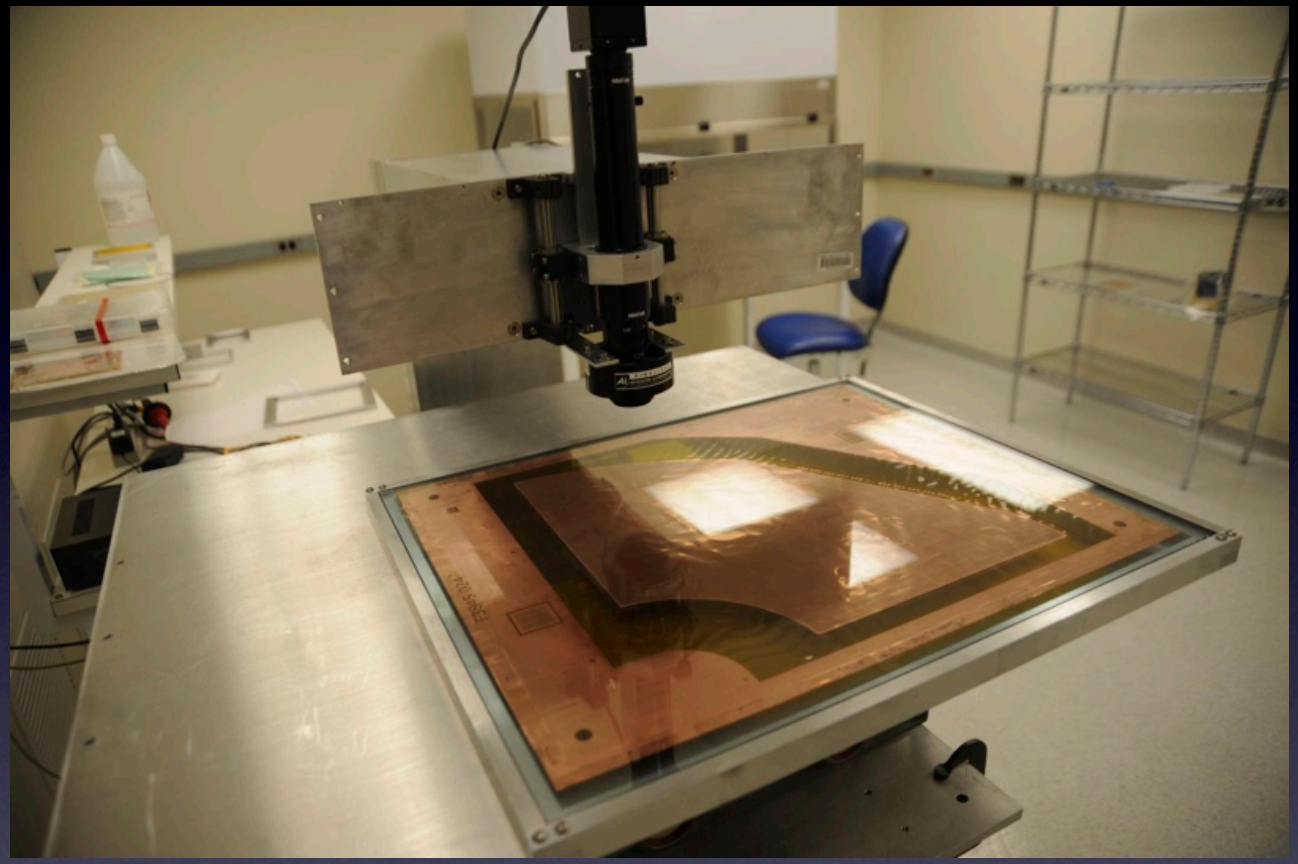


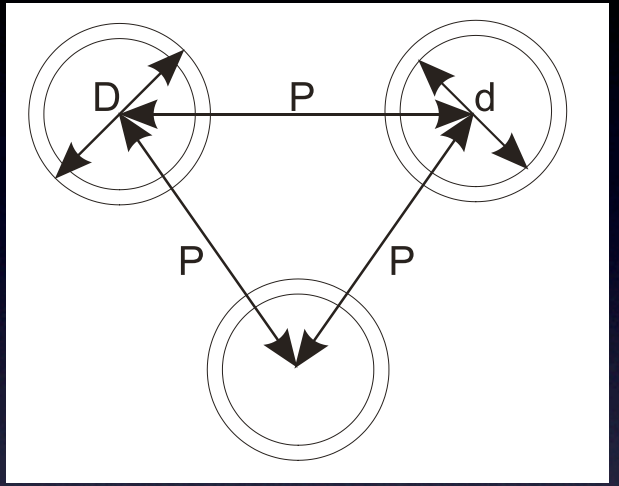


- FNAL test beam 4-32GeV
- Y resolution not affected by tilt.

F. Simon et al., NIM A598 (2009) 432.

Optical Scans





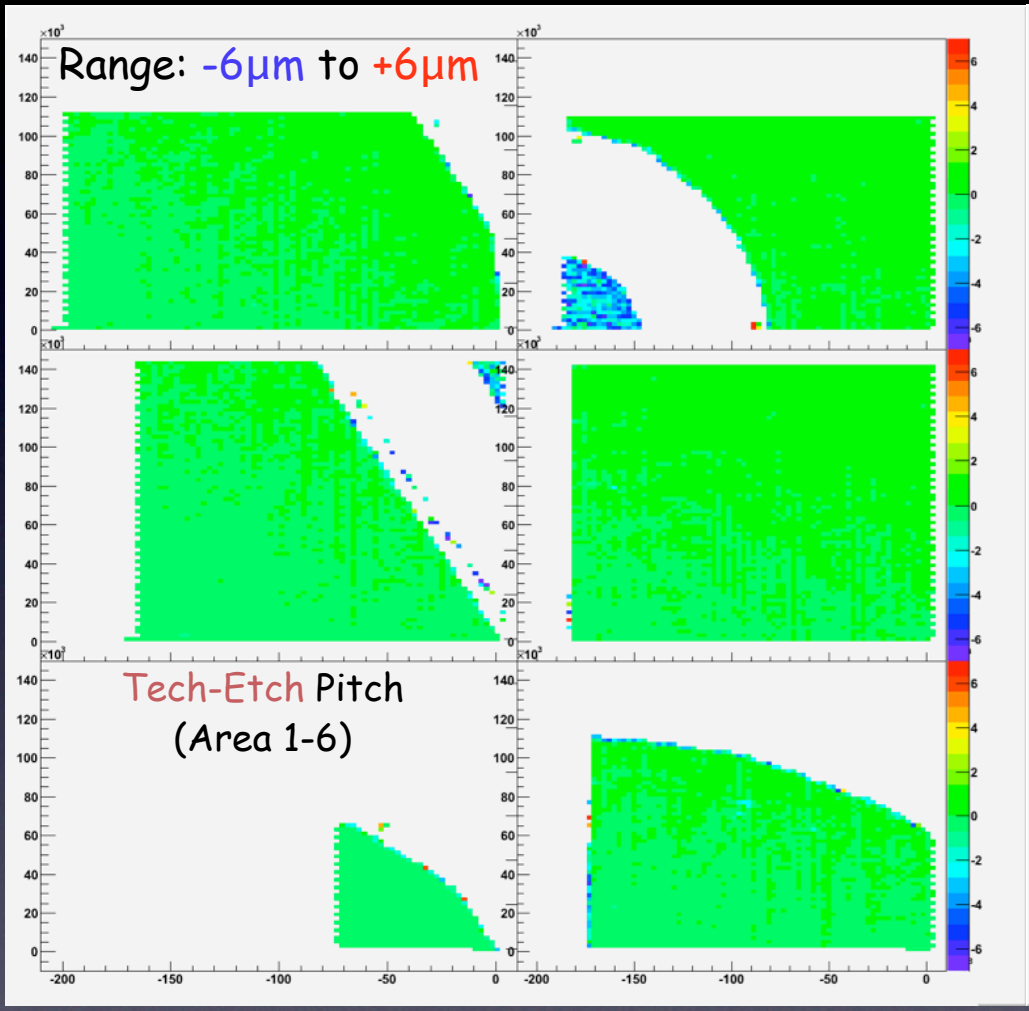
Pitch (P) 140 μm

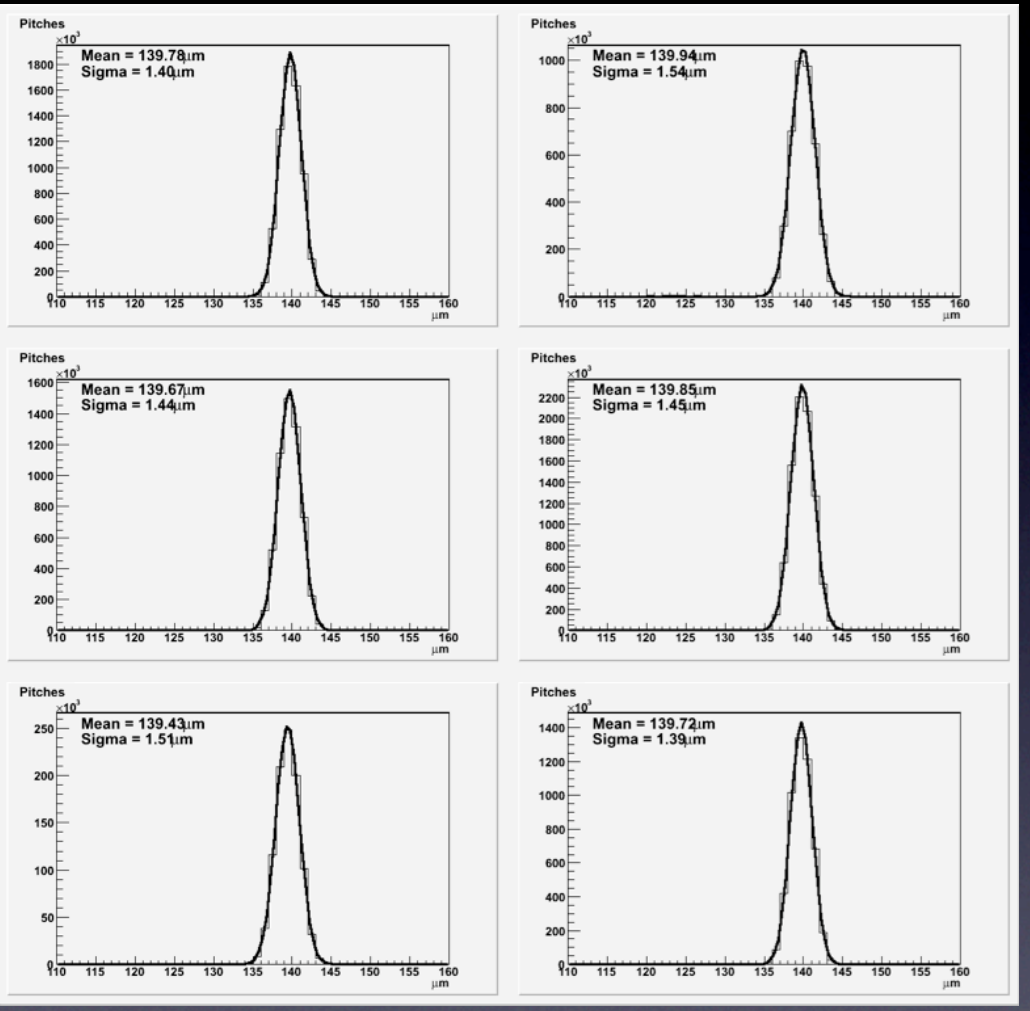
Outer diameter (D) 70 μm

Inner diameter (d) 50 μm

- Measures pitch, inner and outer radii, and offset of hole centers
- Variations can cause position dependence in resolution and gain

Optical Scans



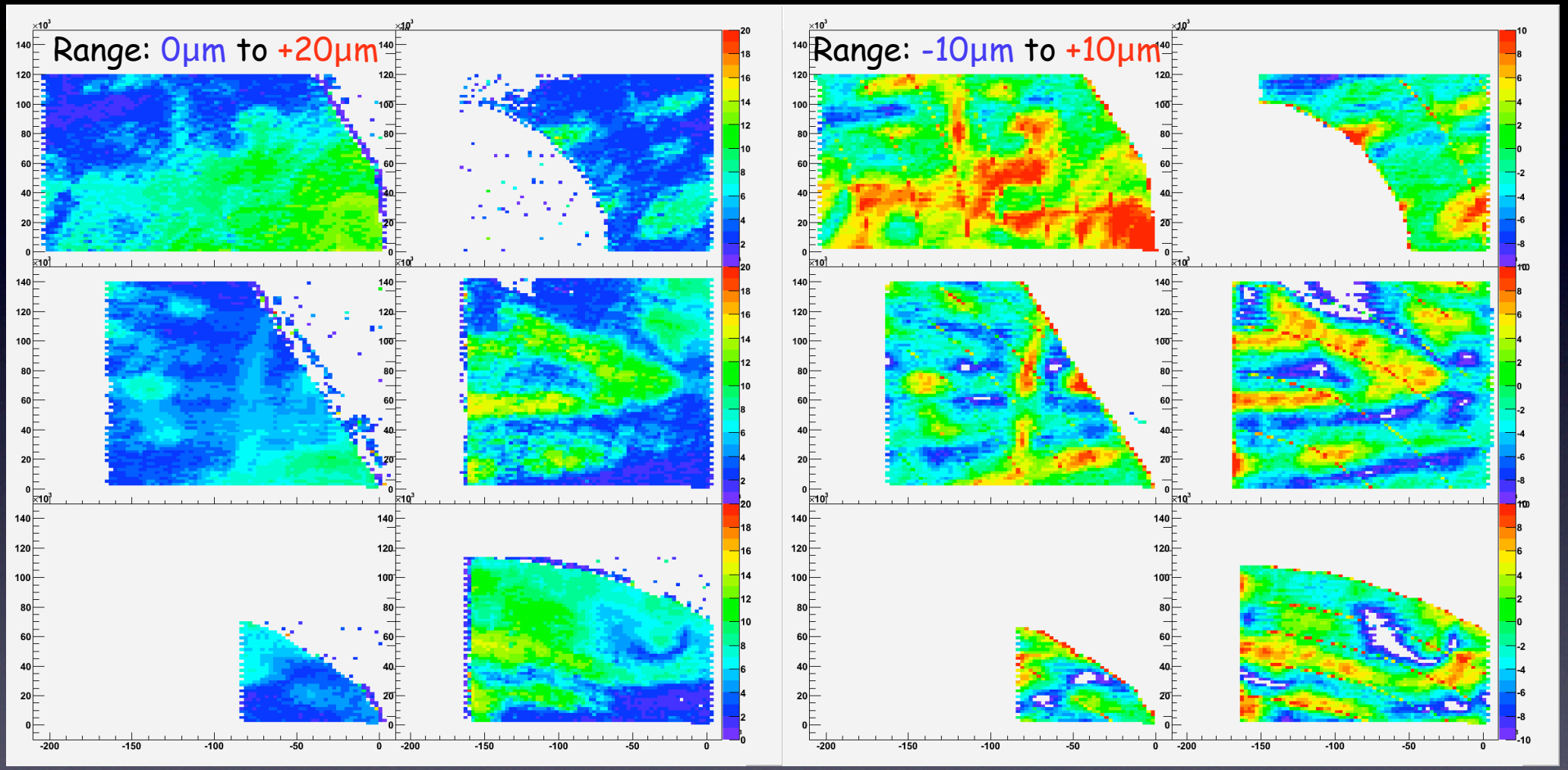


- Pitch is uniform to within a few percent.

Old Optical Scans

Offset

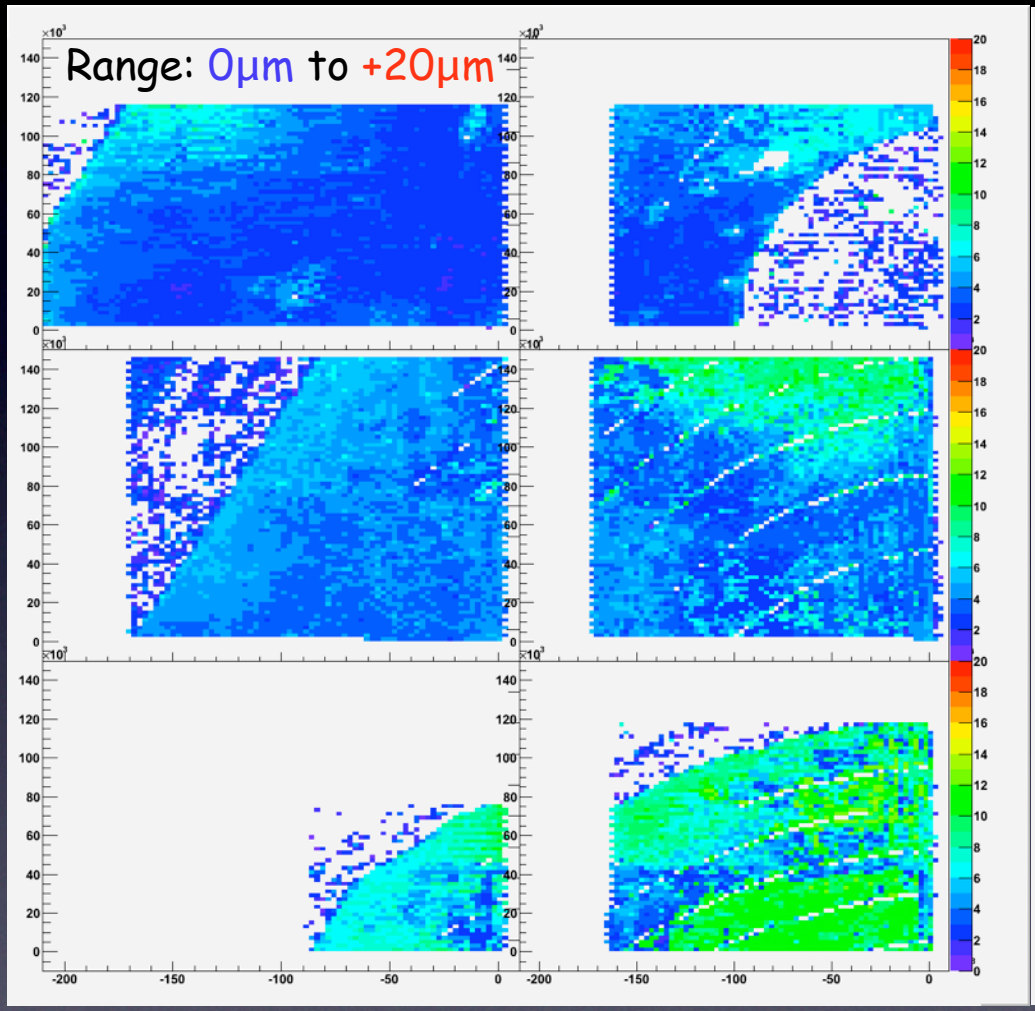
Outer Diameter



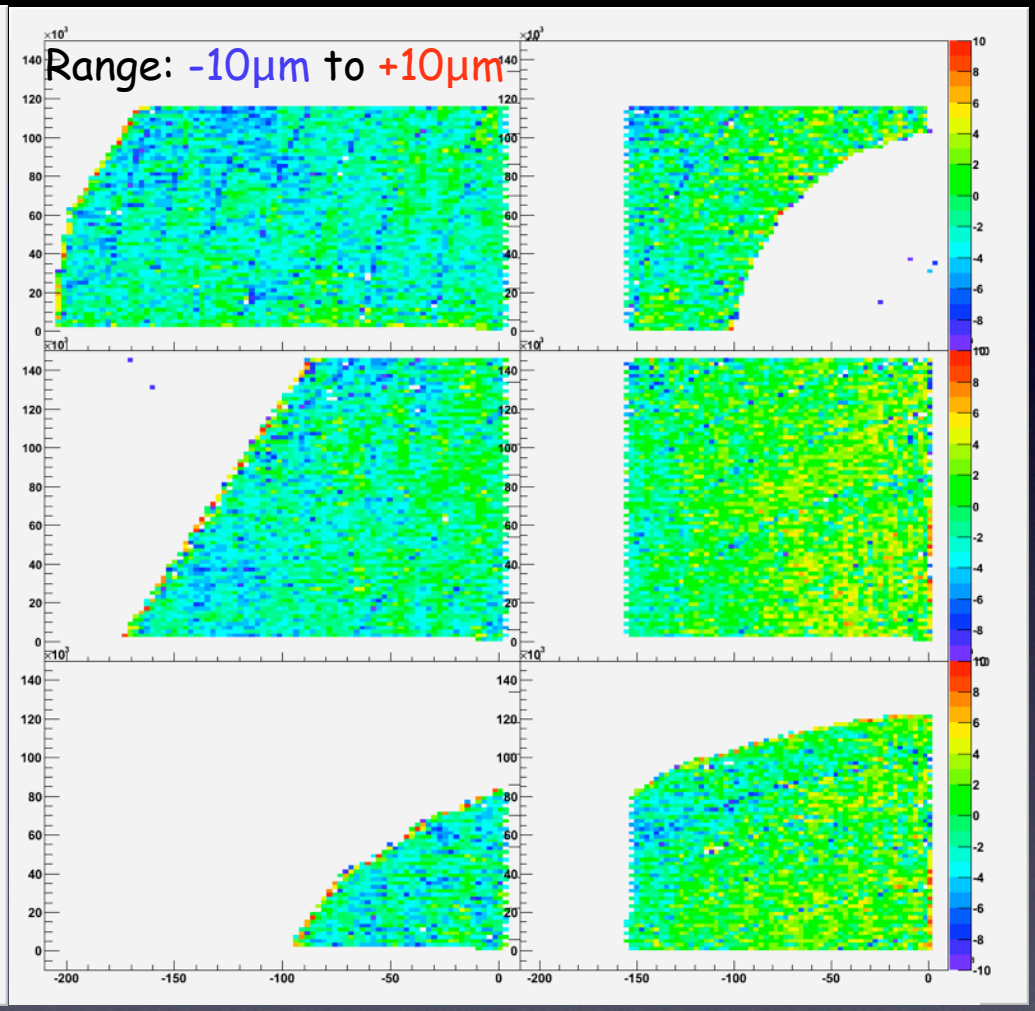
- Early showed significant nonuniformities in hole offset and diameter

New Optical Scans

Offset

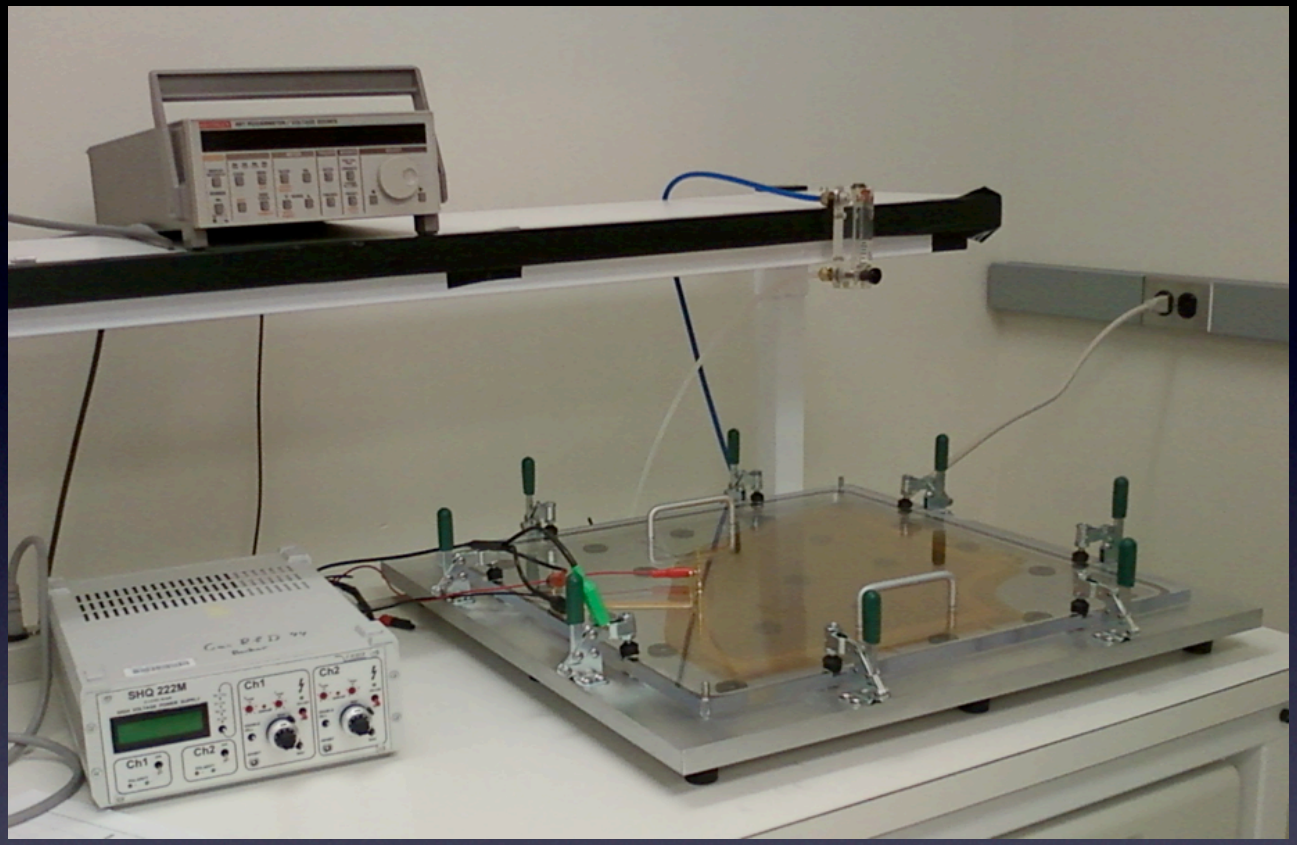


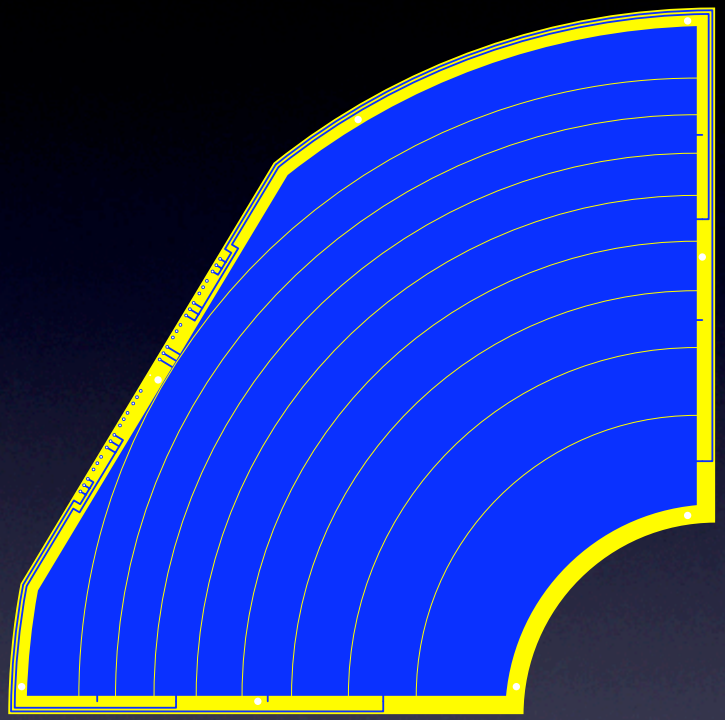
Outer Diameter



- By allowing the foils to relax longer in the vacuum beneath the mask, uniformity is improved.

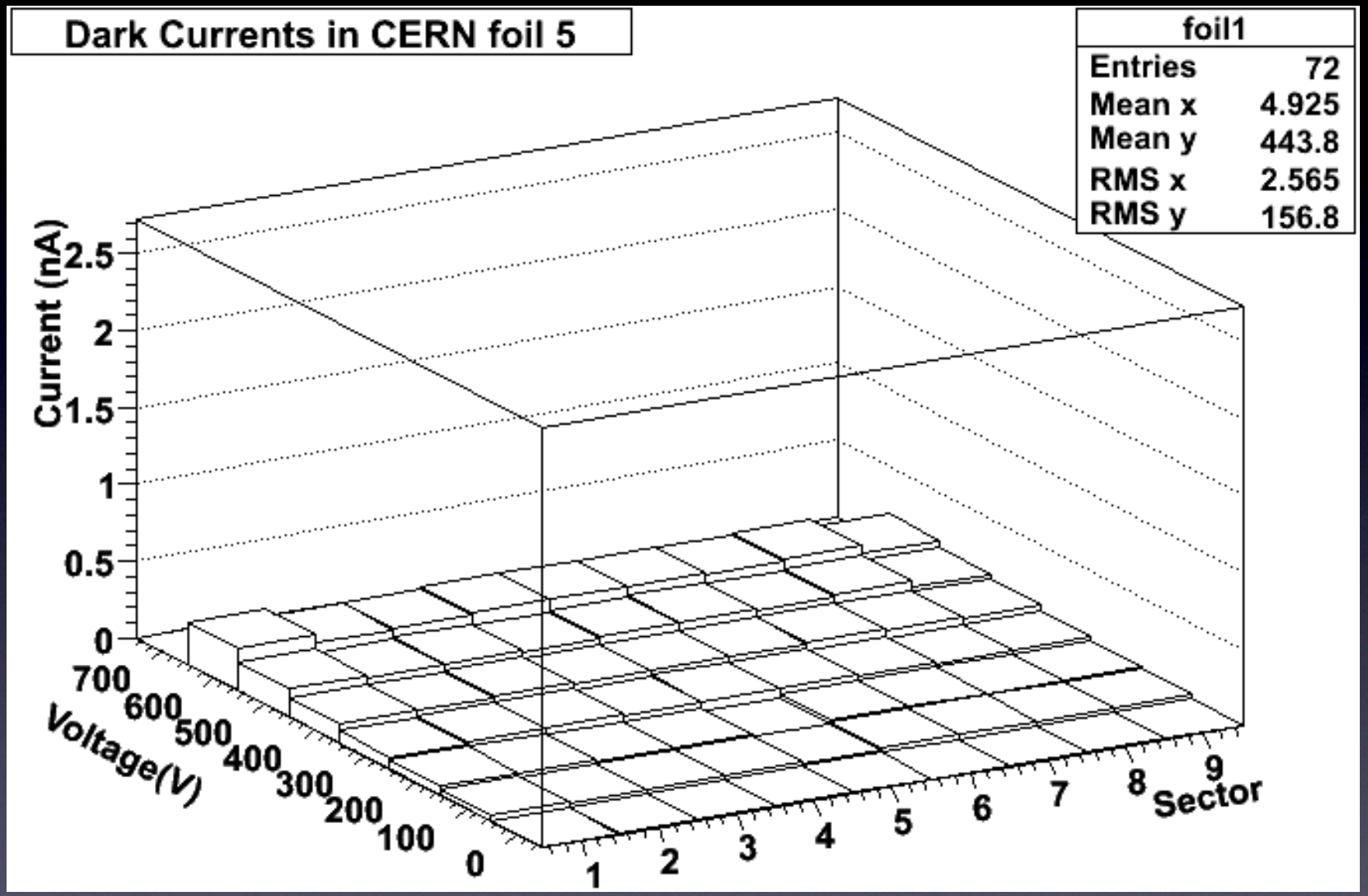
HV Tests





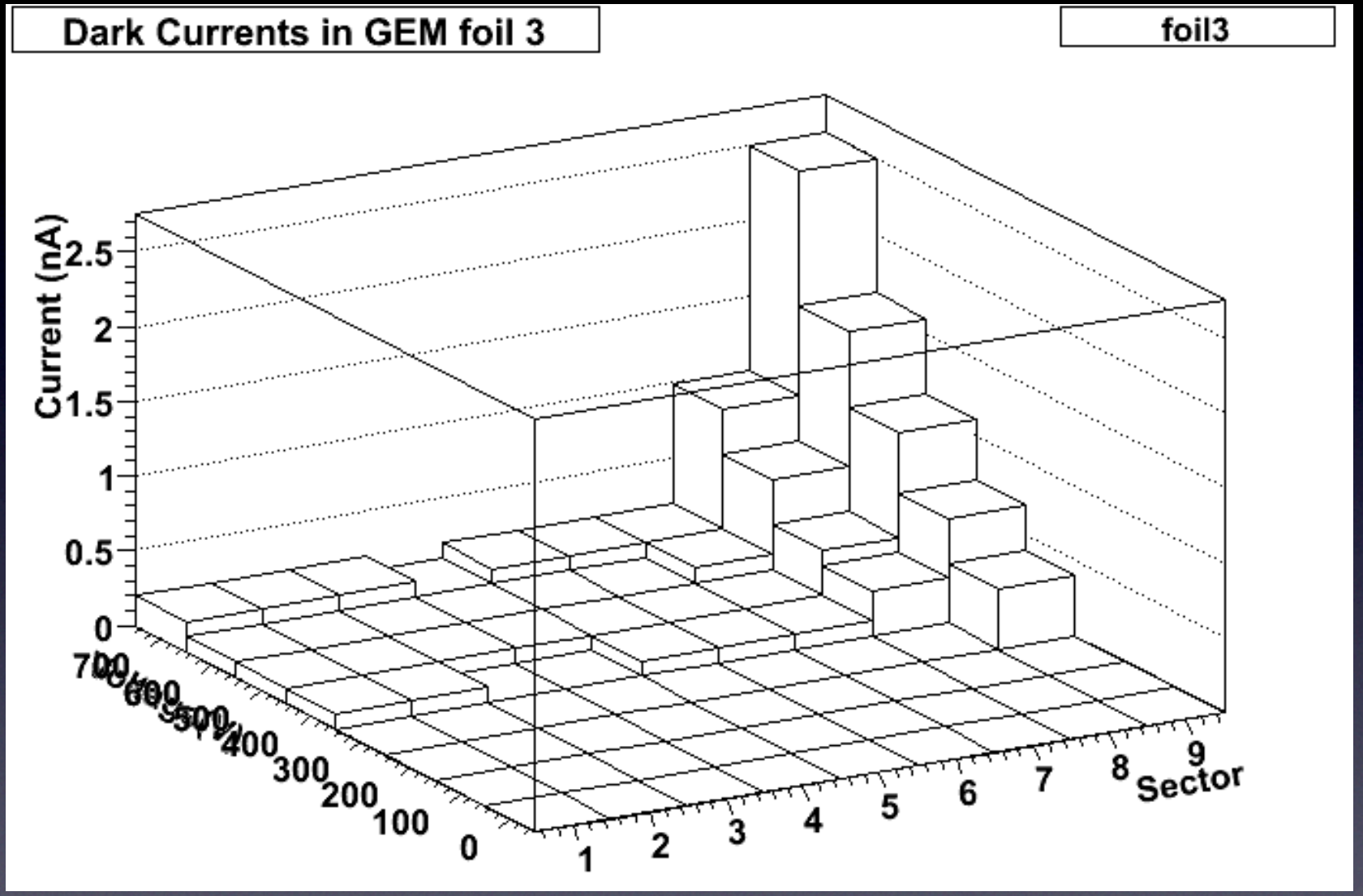
- Measure leakage current in each sector as a function of voltage
- High leakage currents can limit gain

HV Tests



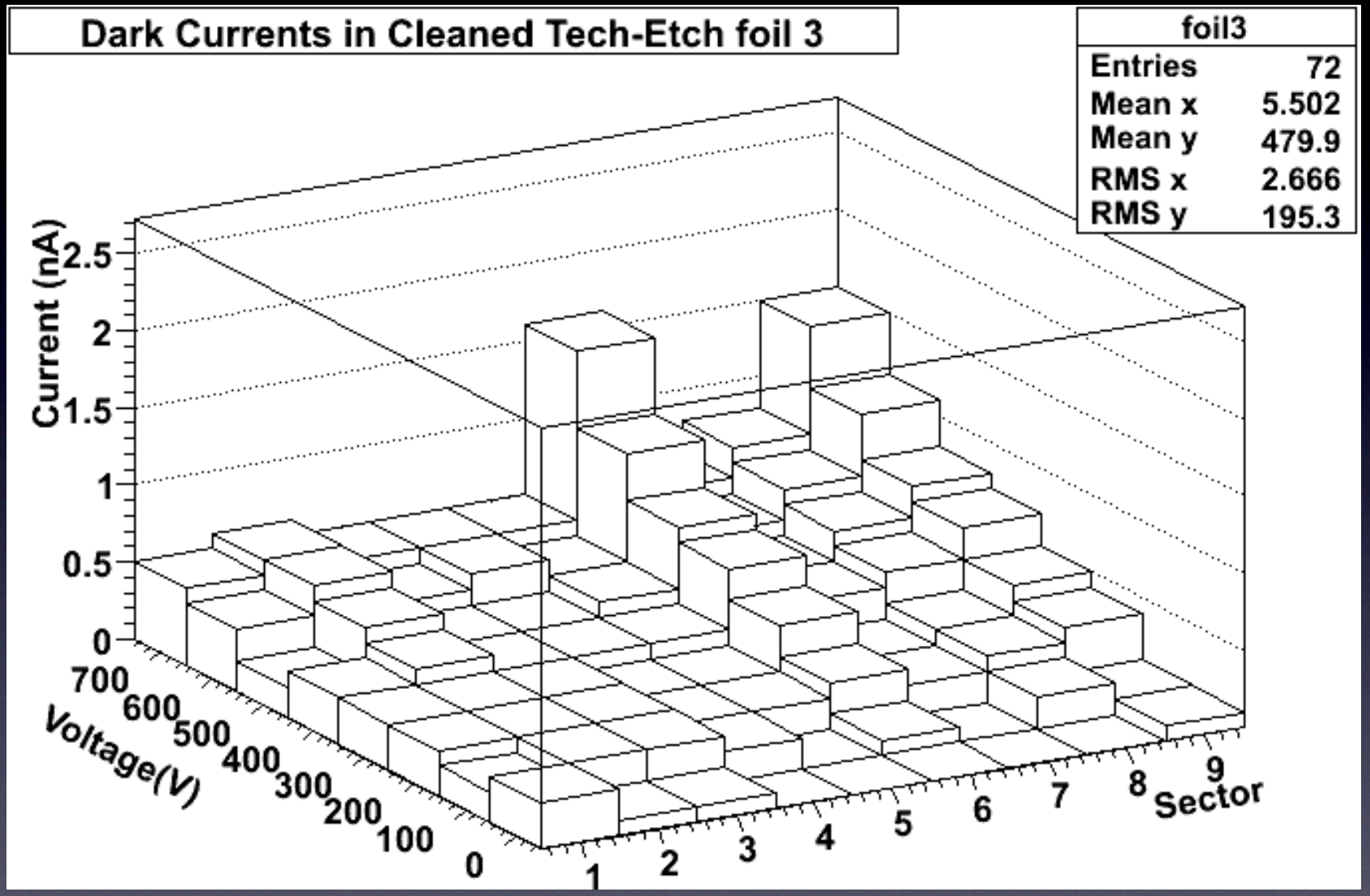
- CERN foils flat vs sector, small linear rise vs V

HV Tests



- First batch of Tech-Etch foils show rapid rise in outer sectors

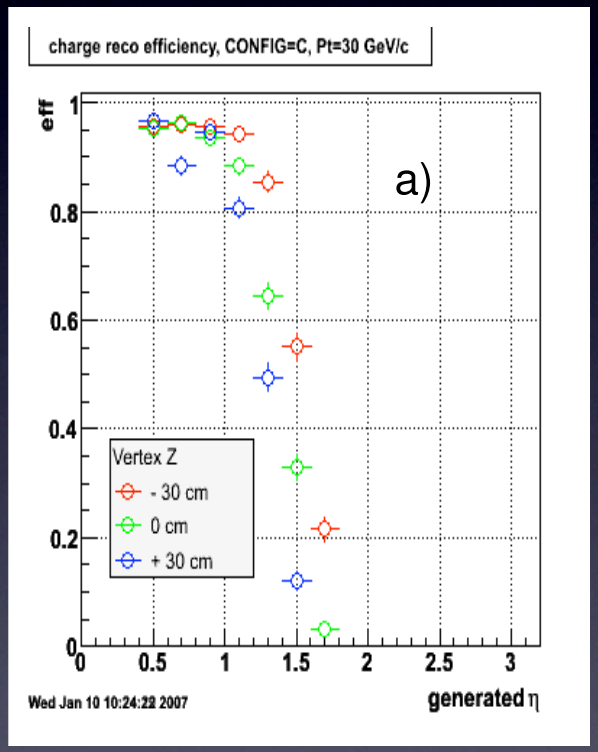
HV Tests

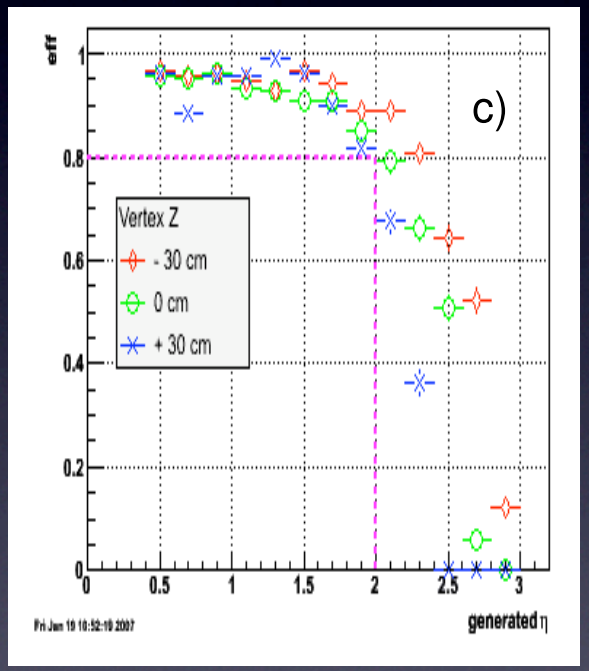


- After cleaning, foils are more uniform
- New foils have dark currents comparable to CERN

Simulation

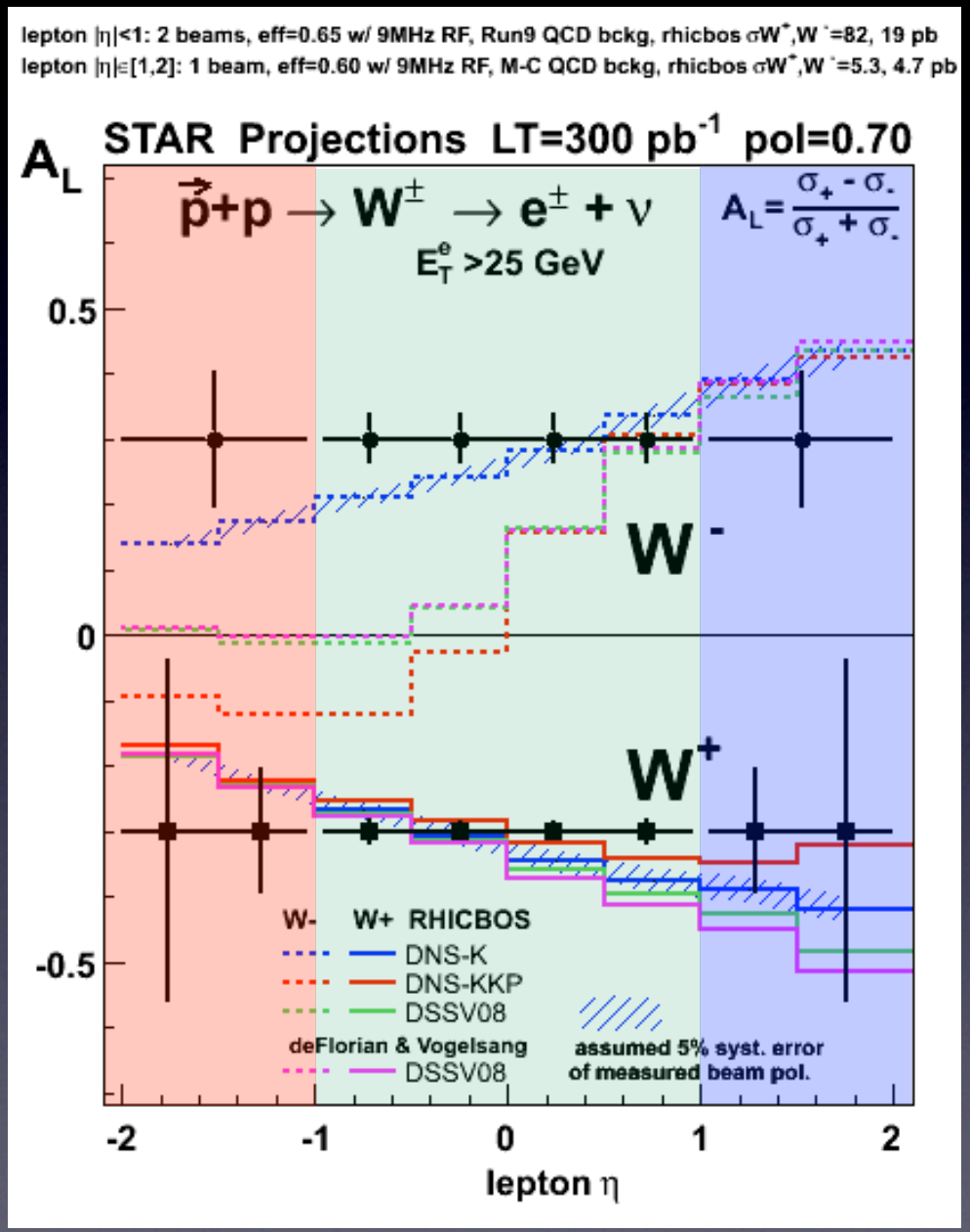
- Without FGT, charge reconstruction falls off sharply for η>1





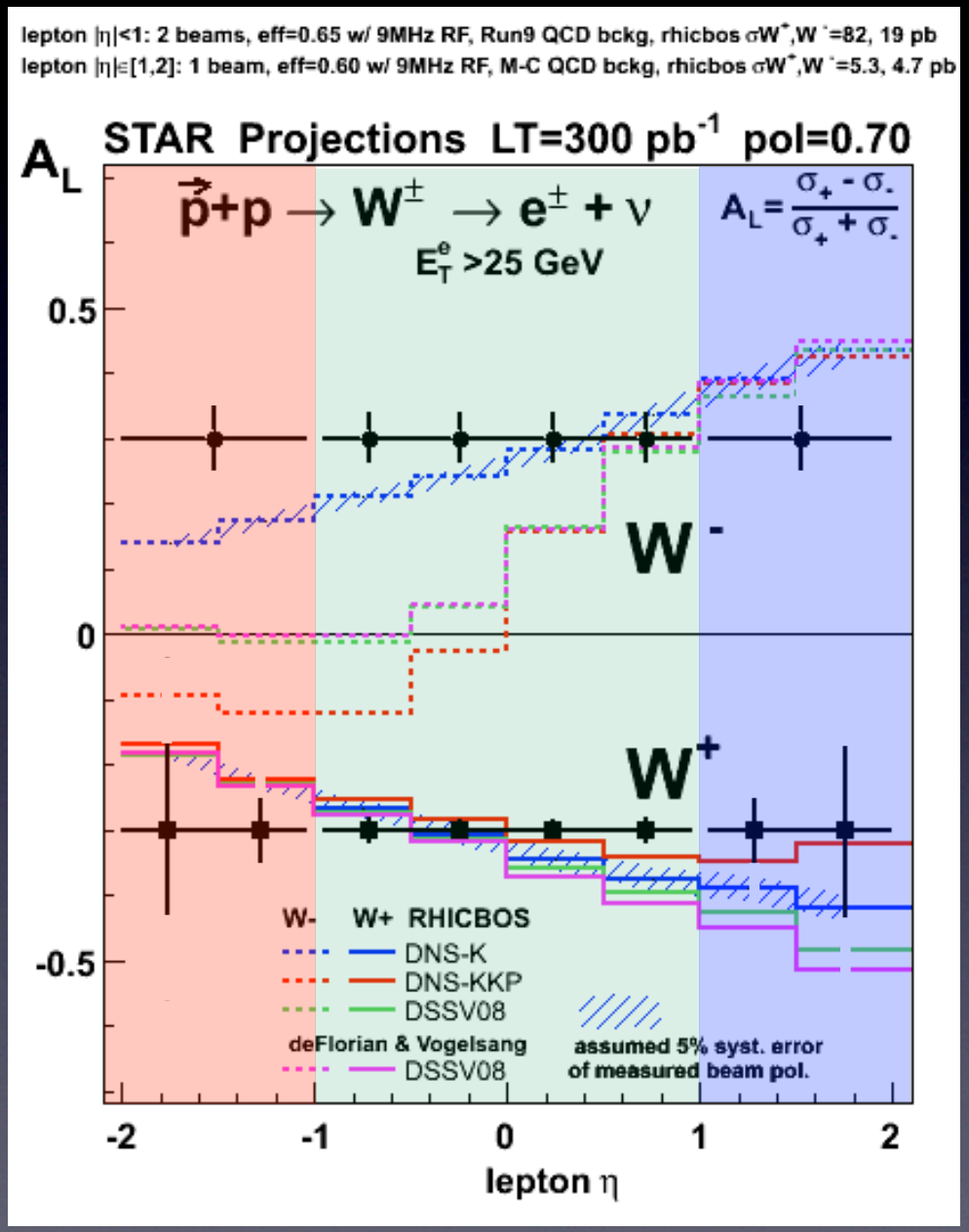
- With FGT, reconstruction is ~90% over 1<η<2

W Projections with the FGT



- With FGT, STAR reach for W A_L is extended
- 300 pb^{-1}, 70% pol.
- forward region error bars from MC study before 2009

W Projections with the FGT



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- 300 pb^{-1}, 70% pol.
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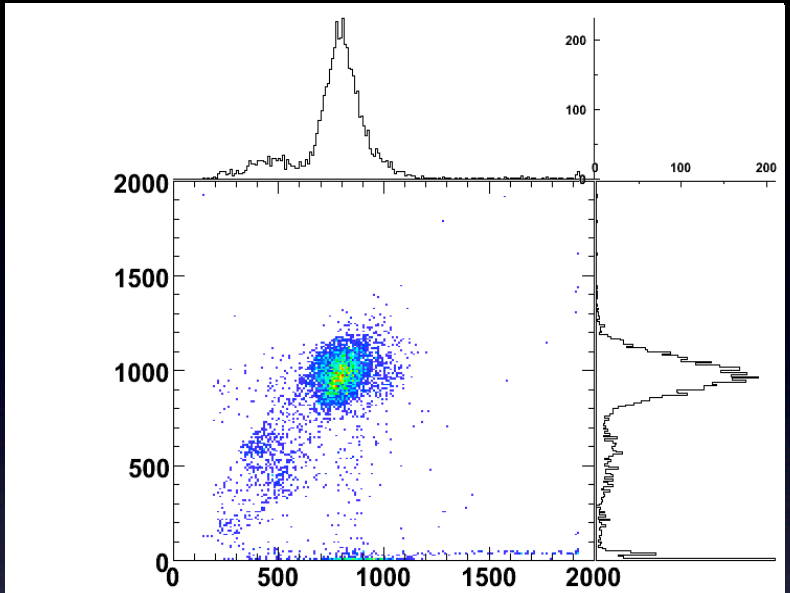
Summary

- FGT provides tracking in $1<\eta<2$
- Nonuniformity in hole diameters and offsets has been reduced to acceptable levels
- With careful handling, leakage currents can be kept at levels comparable to CERN foils
- On track for installation in 2011
- With the FGT, STAR can measure A_L in regions where current fits disagree
- Dedicated 500GeV runs are needed

Radioactive Source Test

- 2D readout plane on small prototype
- Reasonable Fe-55 x-ray spectrum
- Energy resolution ~20%



X-Y energy correlation (arb. units)